

# Non-systemic metamorphosis in Callipodida (Myriapoda, Diplopoda): the case of an endemic Balkan millipede *Apfelbeckia insculpta* (L. Koch, 1867)



Bojan Ilić\*, Jelena Milovanović, Vukica Vujić, Zvezdana Jovanović, Vladimir Tomić, Luka Lučić, Slobodan Makarov

University of Belgrade, Faculty of Biology, Studentski Trg 16, 11000 Belgrade, Serbia



\*Corresponding author: bojan.ilic@bio.bg.ac.rs

## Introduction

- Gonopods are specialized appendages of the seventh diplosegment (where they replace anterior and/or posterior walking leg-pairs during ontogeny) in males of millipede (Diplopoda) clade Helminthomorpha.
- These appendages are involved in sperm transfer and their organization is highly complex and represents the most important morphological character for millipede taxonomy.
- Gonopod development is unique case of morphological differentiation during an advanced phase of post-embryogenesis.
- This process is named non-systemic metamorphosis and it encompasses only the morphological transformation of diplosegment that bears gonopods.
- The aim of this study was to analyse non-systemic metamorphosis in *Apfelbeckia insculpta* (L. Koch, 1867), an endemic Balkan callipodidan millipede that undergoes teloanamorphic mode of post-embryonic development.

## Material and Methods

### Hadži Prodanova Pećina Cave (southwestern Serbia)



### Analysis of post-embryonic development



### Dissections

### Scanning electron microscopy

## Results and Discussion

- Gonopod rudiments are firstly observed at the stadium VIII and they are simple finger-like structures (Figure 1).

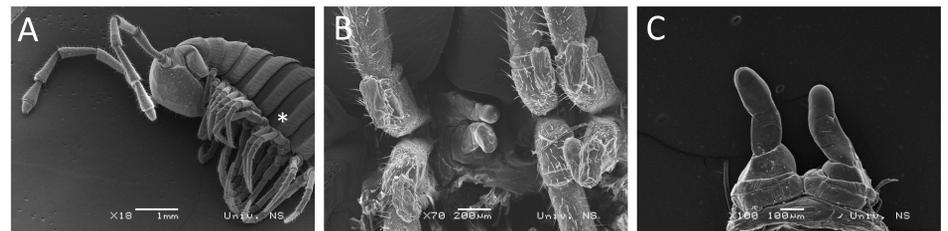


Figure 1. The last stadium (stadium VII) with both pairs of walking legs on the seventh diplosegment (asterisk) (A); gonopod primordia (stadium VIII), ventral view (B); left-right asymmetry of gonopod primordia (C).

- At the stadium IX, gonopod precursors are enlarged and dilated at the base (Figure 2).

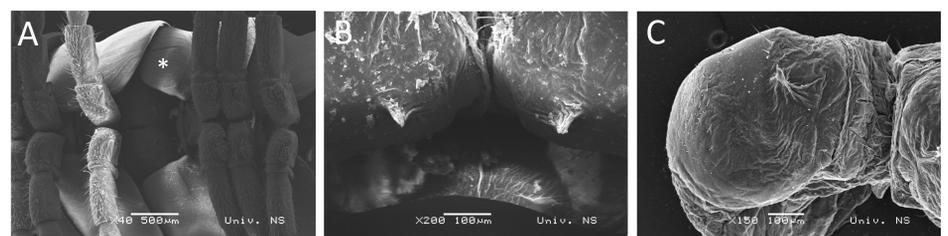


Figure 2. Gonopod precursors are withdrawn below pleurotergite margin of the seventh diplosegment (asterisk) at the stadium IX (A); apical tips of left and right gonopod precursors, ventral view (B); left gonopod precursor (C).

- With the final molt (stadium X), gonopods acquire complex morphology with fully developed branches, processes, solenomere and parasolenomere (Figure 3).



Figure 3. The seventh diplosegment (asterisk) with completely developed gonopods at the stadium X (adult stadium), ventral view (A); detail of figure A with solenomere and parasolenomere (B); left and right gonopod, posterior view (C); outer branches, anterior view (D); outer branches, sponge-like processes and inner branches, posterior view (E); right gonopod, mesal view (F); detail of figure F with tarsal process and seminal groove (arrow) (G); detail of figure F with solenomere, parasolenomere and seminal groove (arrow) (H). Abbreviations: a = coxal process 2; h = process on t; i = isthmus, ib = inner branch; k = sponge-like process; ob = outer branch; p = coxal process 1; ps = parasolenomere; s = solenomere; st = sternum; t = tarsal process.

## Conclusion

- Non-systemic metamorphosis in *A. insculpta* shares the pattern also observed in millipede order Polydesmida.